



STAR-Dundee

20 Years of Spacecraft Networking Innovation

SpaceWire Test and Development with STAR-System and the SpaceWire PCIe Mk2

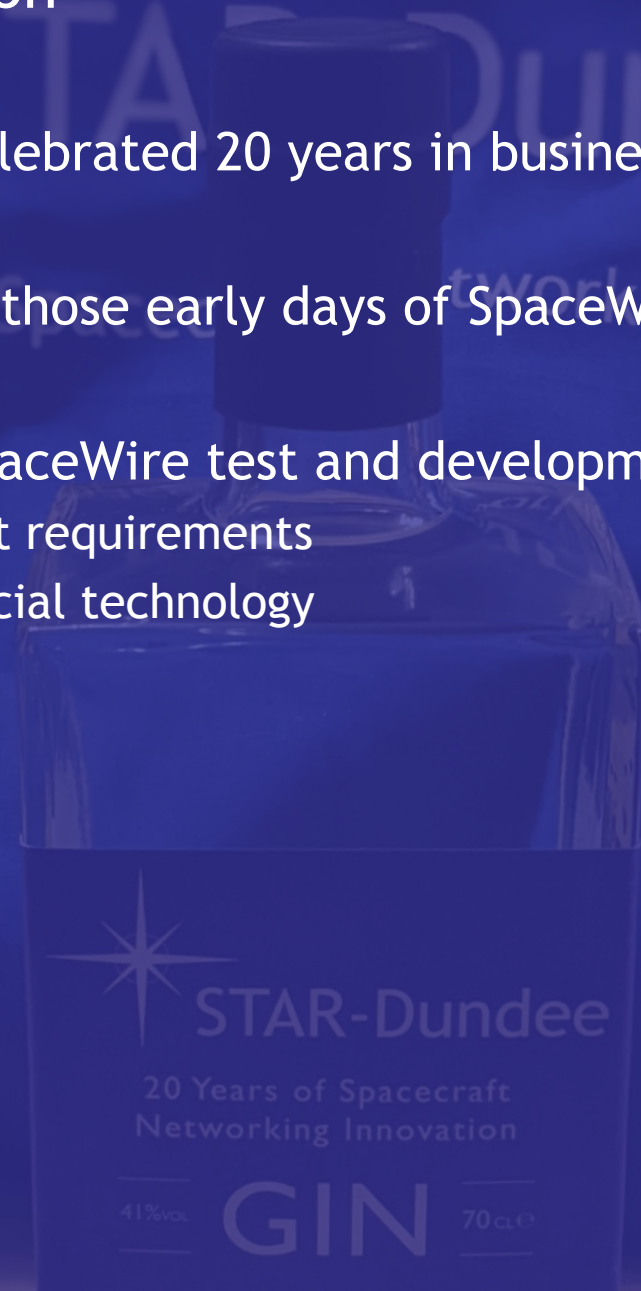
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www.star-dundee.com

@STAR_Dundee

Introduction

- In July, STAR-Dundee celebrated 20 years in business
- Much has changed since those early days of SpaceWire
- The requirements for SpaceWire test and development products continue to evolve
 - Influenced by spacecraft requirements
 - And changes in commercial technology



The SpaceWire PCI-2

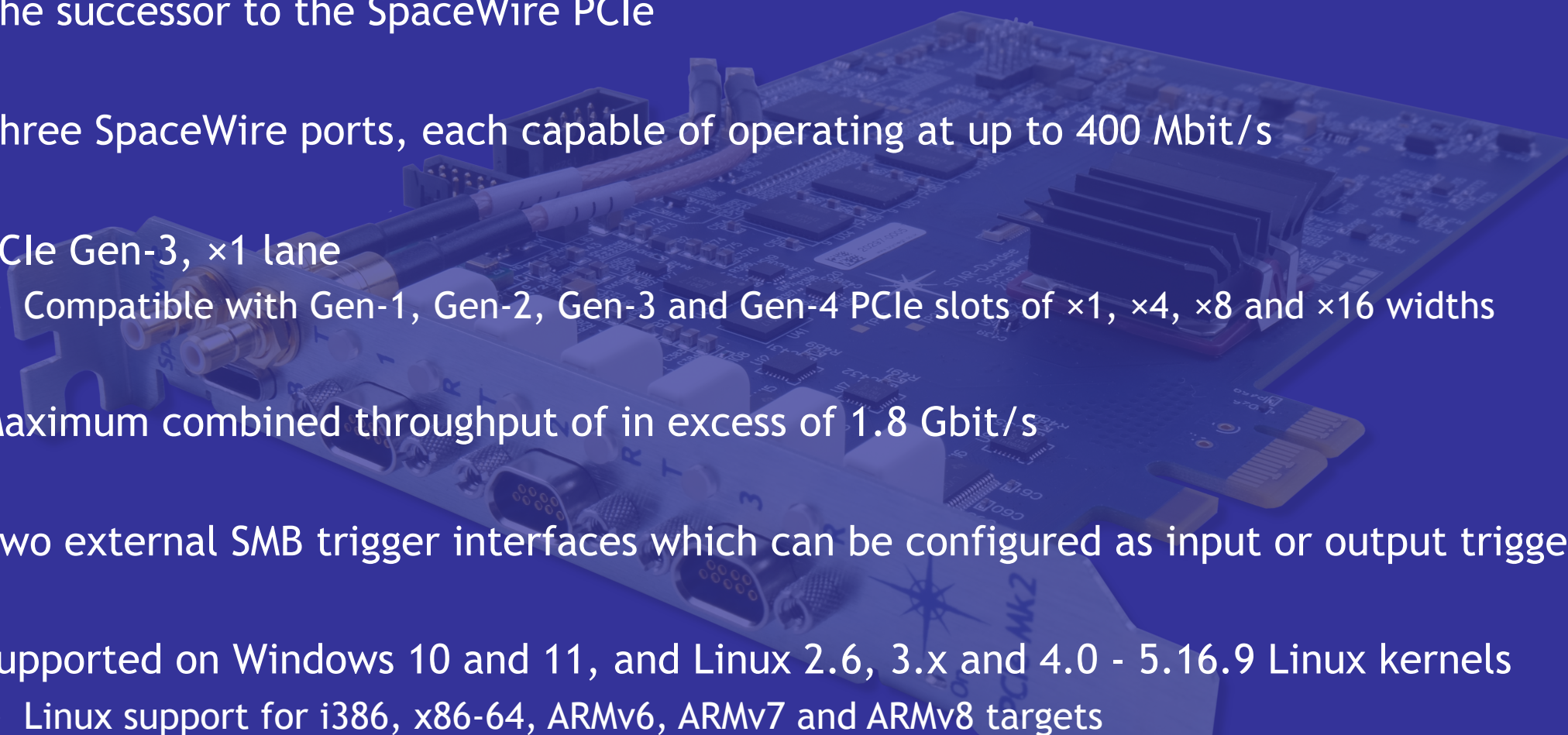
- Three SpaceWire ports, each capable of operating at up to 200 Mbit/s
- Maximum combined throughput of around 700 Mbit/s
 - Limited by the PCI bus
- Initially supported on i386 Windows 2000 and XP
 - Support for i386 Linux 2.4 kernels added later
- Software access was through a C API
 - With some basic example command-line applications



The SpaceWire PCIe

- Released in 2012
 - Three SpaceWire ports, each capable of operating at up to 300 Mbit/s
 - PCIe Gen-1, ×1 lane
 - Maximum combined throughput of around 800 Mbit/s
 - Limited by the hardware interface to the PCIe bus
 - One of the first devices to be supported by STAR-Dundee's STAR-System software suite
 - Common platform for accessing several device types
 - Includes APIs with examples and comprehensive documentation
 - Along with graphical applications for common tasks
 - Initially supported on i386 and x86-64 Windows XP, Vista and 7, and Linux 2.6 and 3.x kernels
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The SpaceWire PCIe Mk2

- The successor to the SpaceWire PCIe
 - Three SpaceWire ports, each capable of operating at up to 400 Mbit/s
 - PCIe Gen-3, ×1 lane
 - Compatible with Gen-1, Gen-2, Gen-3 and Gen-4 PCIe slots of ×1, ×4, ×8 and ×16 widths
 - Maximum combined throughput of in excess of 1.8 Gbit/s
 - Two external SMB trigger interfaces which can be configured as input or output triggers
 - Supported on Windows 10 and 11, and Linux 2.6, 3.x and 4.0 - 5.16.9 Linux kernels
 - Linux support for i386, x86-64, ARMv6, ARMv7 and ARMv8 targets
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PCIe Mk2 Fault Protection

- Includes extensive fault protection to meet most FMEA (Failure Mode and Effects Analysis) compliance requirements
- Covers:
 - Input power voltages from the host PC
 - Overvoltage of any of the point of load converters on the board
 - Output voltage on the SpaceWire ports
 - Trigger output voltage
- SpaceWire ports are cold-sparing so that the board can be powered down without adversely affecting any system it is connected to by a SpaceWire link
- SpaceWire LVDS transmitters can be tri-stated

STAR-System and The PCIe Mk2

- C, C++ and Python APIs provided
 - With example command-line applications and comprehensive documentation
 - LabVIEW API available separately
- Graphical applications for performing common tasks, e.g.:
 - Transmitting and receiving packets
 - Transmitting and receiving time-codes
 - Configuring devices
 - Injecting errors
- Recent new features include:
 - API to support CCSDS Space Packet Protocols
 - RMAP Initiator graphical application
 - Data rate graphs in the Source and Sink graphical applications

Backwards Compatibility and Support

- STAR-System provides a consistent interface for all supported devices, while being backwards compatible
 - Making it possible to use applications developed for the SpaceWire PCIe or other STAR-System devices with the PCIe Mk2
 - No need to update code or recompile
- The PCI-2 was updated to be the PCI Mk2 in 2011 through new FPGA code
 - And continues to be supported in STAR-System
- STAR-System is regularly updated with support for new devices, targets and operating system releases
 - While new features are also added
- A Device Update graphical application is included with STAR-System
 - Which can be used to easily update the device
- In the unlikely event a hardware bug is found, updates can be made available on our website
- More often, however, this is used to add new functionality to devices
 - E.g. packet timestamping was added to the PCIe several years ago
 - And is included in the PCIe Mk2

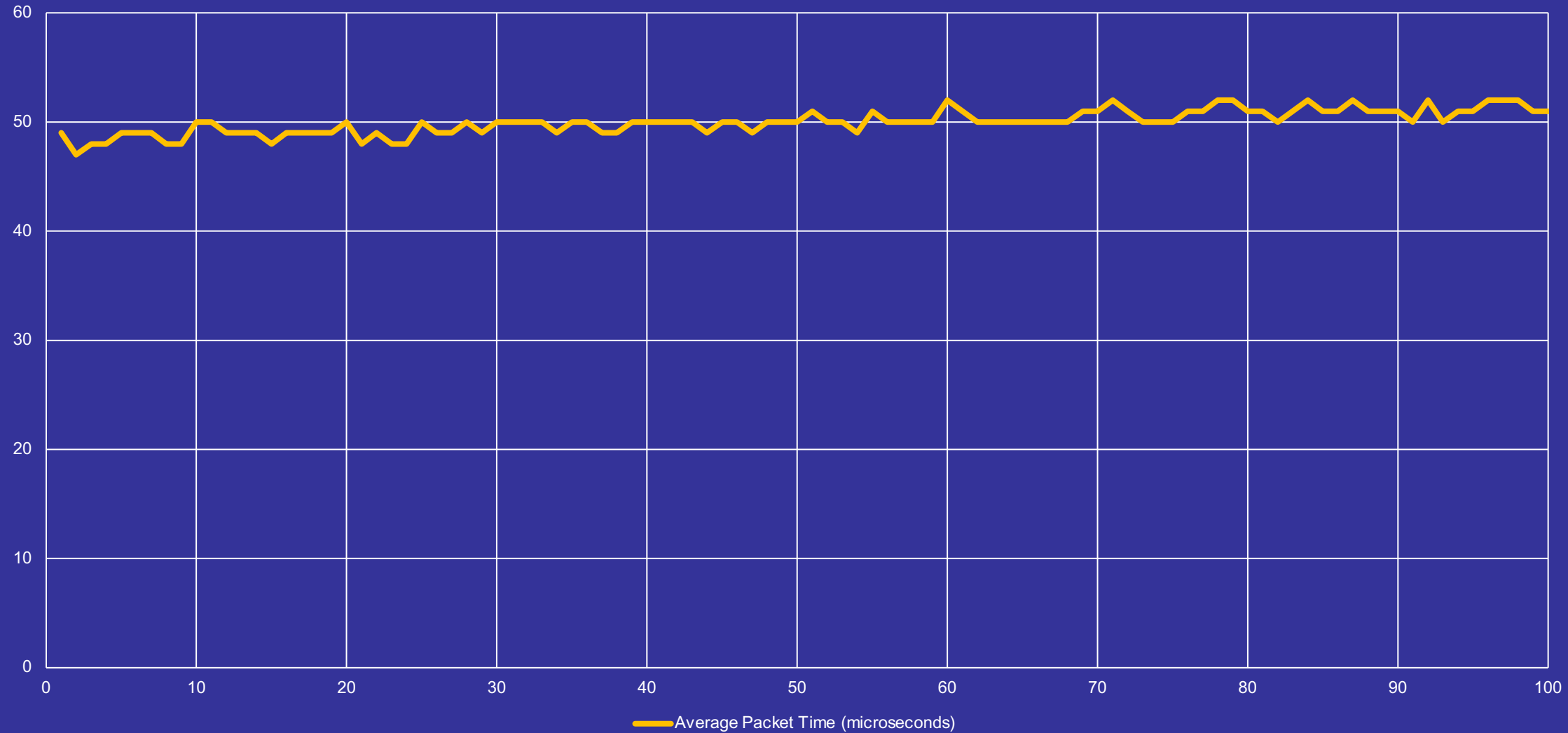
PCIe Mk2 Triggering Capabilities

- The PCIe Mk2 has further triggering capability besides the external trigger interfaces
- Configured using STAR-System's Triggering API or a new Triggering graphical application
- Can be used to trigger an action to be performed when an event occurs
 - Event may be a signal on one of the external trigger interfaces, a packet being received or an error occurring on the link
 - Action may be to transmit a packet or time-code or to signal on one of the trigger interfaces
- Several event and action types are supported, including counters which can be used to ensure an action occurs at a specific time
- These actions and events can then be combined to provide deterministic behaviour, even when using a non-deterministic operating system
 - The hardware is responsible for determining when an action should take place

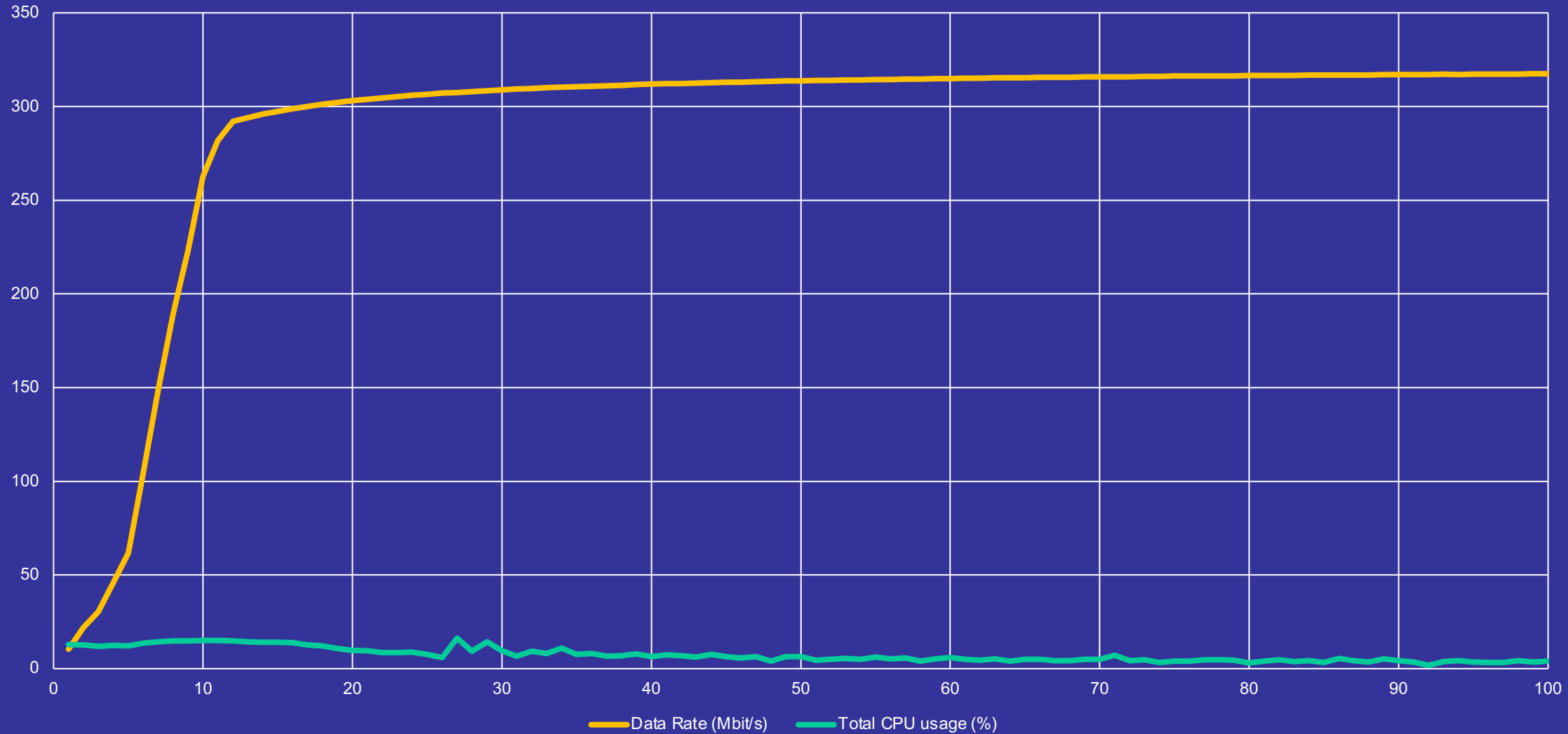
Performance of the PCIe Mk2

- STAR-System has been designed to provide high throughput, low latency and low CPU usage
- While devices such as the PCIe Mk2 are designed to provide a high performance interface to the software
- A command-line application, the Performance Tester, is included with STAR-System to test these capabilities
- The following slides show the results from tests of the PCIe Mk2 on a PC with the following specification:
 - ASUS PRIME H310i PLUS R2.0 Motherboard
 - Intel Core i5 Six Core Processor i5-9600 (3.1GHz) 9MB Cache
 - 8 GB Corsair VENGEANCE DDR4 2400MHz
 - 240 GB ADATA SU630 SSD
- Dual-bootable, allowing tests to be performed on Windows 10 and Linux
- Link speeds set to 400 Mbit/s on PCIe Mk2

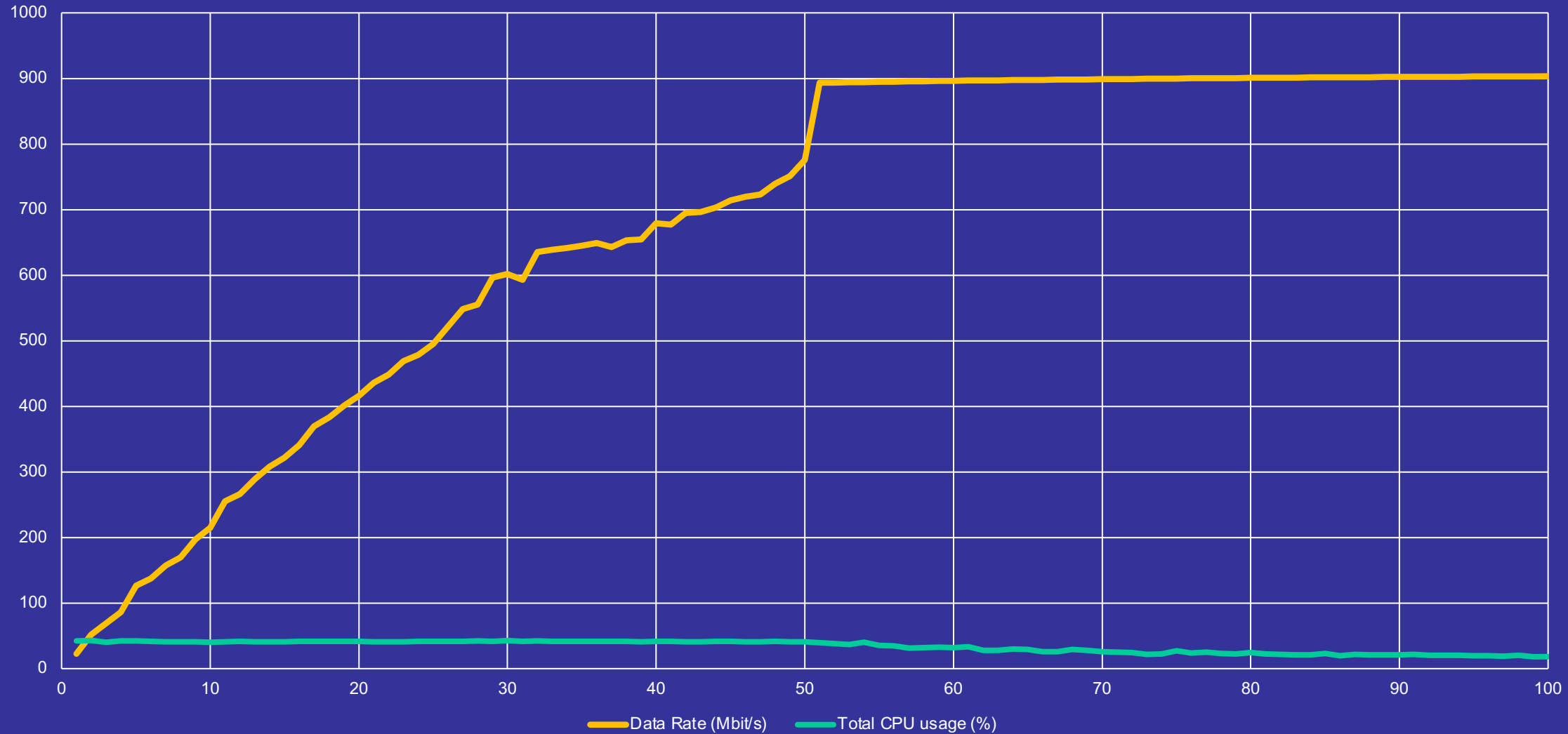
PCIe Mk2 Latency Test



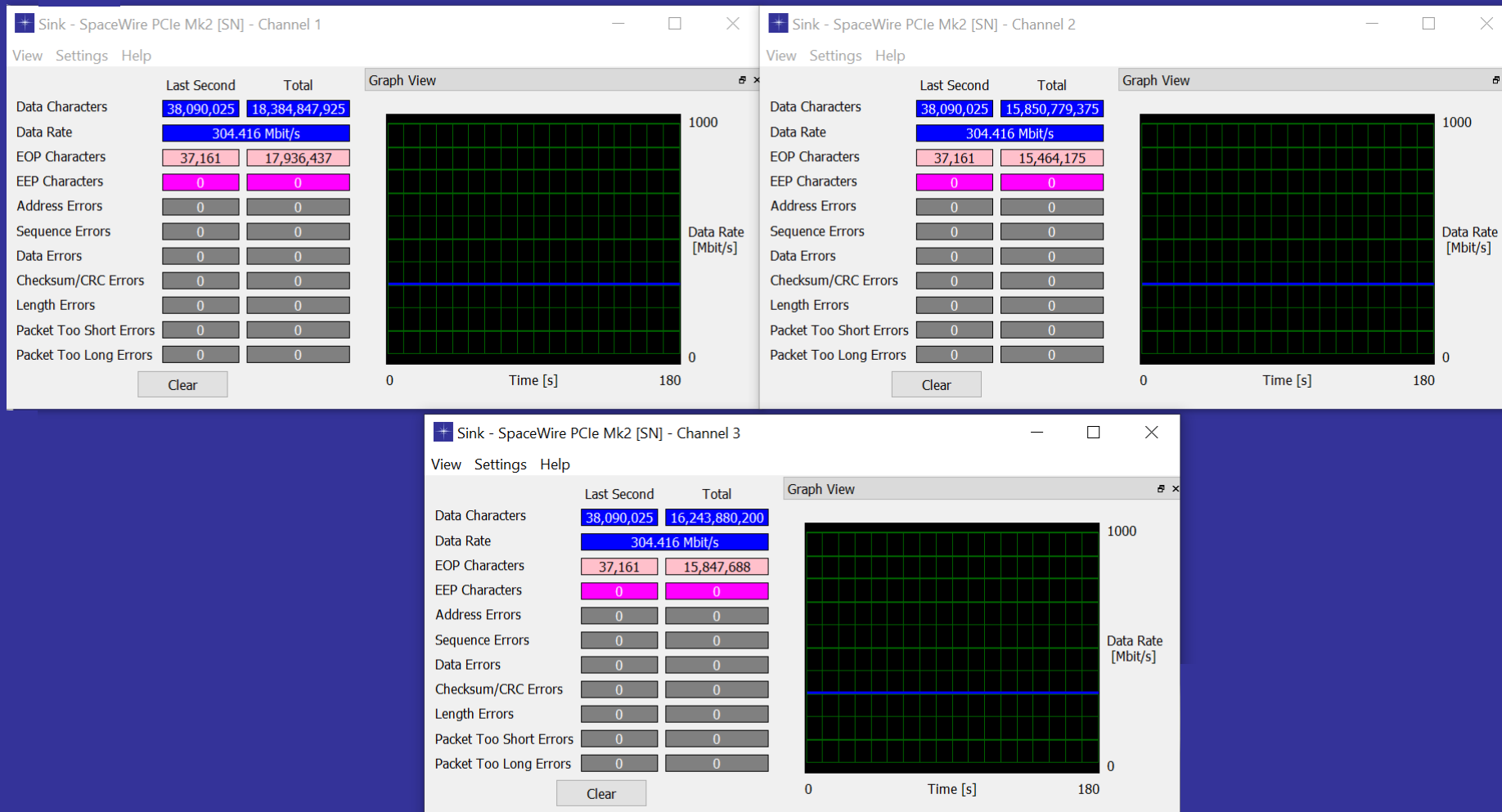
PCIe Mk2 Single Loopback Test



PCIe Mk2 Triple Loopback Test



PCIe Mk2 Source and Sink Triple Loopback Test



Current Status of The SpaceWire PCIe Mk2

- The SpaceWire PCIe Mk2 and STAR-System have been shown to provide extensive functionality and extremely high performance
 - While being backwards compatible with the original SpaceWire PCIe
- STAR-System v5.01 with support for the PCIe Mk2 was released on the 16th of September
 - And is available from our website for registered users with a STAR-System product
- We began accepting orders for the product a few weeks ago
- It will be added to our website soon, replacing the SpaceWire PCIe
- The first boards shipped to customers on Friday
- We have a board being demonstrated on our stand outside
- Thank you for listening!

